


## DECLARATION

I, Tsuneo Kobayashi, a Japanese Patent Attorney registered No. 12864, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No. 2003-115959 filed on April 21, 2003 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

signed this 5th day of February, 2010



Tsuneo Kobayashi

## JAPAN PATENT OFFICE

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[Title of the Invention] Electrophoresis Display

Apparatus

5 [What is claimed is:

[Claim 1]

An electrophoresis display apparatus  
comprising:

a first substrate and second substrate arranged  
10 with a predetermined gap in between;

an insulating liquid and a plurality of charged  
particles enclosed in the gap between these  
substrates;

a first electrode placed along said first  
15 substrate over a relatively wide area of a pixel; and

a second electrode between which and said first  
electrode a voltage is applied, said electrophoresis  
display apparatus carrying out a display by applying  
a voltage to these electrodes and moving said charged  
20 particles,

wherein said charged particles are colored in a  
first color,

at least a portion of the area where said first  
electrode is placed in which the density of said  
25 charged particles cannot be kept high is colored in  
substantially the same color as said first color,

at least a portion of the area where said first

electrode is placed in which the density of said charged particles can be kept high is colored in a second color,

when said charged particles are placed so as to  
5 cover said first electrode, said first color is visually recognized, and

when said charged particles are attracted to said second electrode and accumulated, said second color is visually recognized.

10

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a moving  
15 particle type display apparatus which performs a display based on charged particles which move when a voltage is applied thereto.

[0002]

[Prior Art]

20 Recently, great attention is paid to an electrophoresis display apparatus that performs display by applying a voltage to charged particles to move them.

[0003]

25 This type of electrophoresis display apparatus is provided with a first substrate 1 and a second substrate 2 arranged with a predetermined gap in

between and an insulating liquid and charged particles are placed in the gap between these substrates. Furthermore, each pixel is provided with a first electrode and a second electrode.

5 (1) When charged particles are attracted to the first electrode and scattered over a wide area, the color (e.g., black) of the charged particles is visible.

(2) When charged particles are attracted to the second electrode and concentrated in a narrow area,  
10 the color (e.g., white) of the area where the first electrode is formed is visible.

That is, the display is performed by utilizing a color difference observed in the above mentioned situations (hereinafter, it is referred to as  
15 "horizontal moving type" display).

[0004]

There is also a proposal on a display apparatus constructed in such a way that a shielding layer is placed to hide the second electrode and charged  
20 particles attracted by the second electrode are not visible to the observer (see for example, Patent Document 1).

[0005]

[Patent Document 1]

25 Patent Application Laid-Open No. H09-211499).

[0006]

[Problems to be Solved by the Invention]

However, in the above described electrophoresis display apparatus, with respect to display quality, in the case (1) above, it is desirable that charged particles be scattered over the entire first  
5 electrode at substantially the same density. However, in reality, the density of the charged particles is partially reduced and the "color of the base (that is, the color of the area where the first electrode is formed)" is reflected and made visible. For this  
10 reason, the display quality deteriorates. The reasons for such a phenomenon are not clearly defined but it is thought that one reason therefor lies in that charged particles which should have been originally disposed on a part near the second  
15 electrode are moved, accepting repulsion from the second electrode. As other reasons, the followings can be given.

- When a barrier is placed so as to separate a pixel, this causes the "area where the second  
20 electrode is formed" and areas adjacent thereto not to become level but inclined and as a result, the charged particles may be hardly at rest.

- In the case that inner sides of the barrier and the pixel are coated, a repulsive force is generated  
25 between the coating material and the charge particles and hence the charged particles may be hardly at rest.

[0007]



Therefore, an object of the present invention is to provide an electrophoresis display apparatus preventing deterioration of the display quality.

[0008]

5 [Means for Solving the Problems]

The present invention has been made in view of the above mentioned circumstances. Therefore, according to the present invention, there is provided an electrophoresis display apparatus comprising: a  
10 first substrate and second substrate arranged with a predetermined gap in between; an insulating liquid and a plurality of charged particles enclosed in the gap between these substrates; a first electrode placed along the first substrate over a relatively  
15 wide area of a pixel; and a second electrode between which and the first electrode a voltage is applied, the electrophoresis display apparatus carrying out a display by applying a voltage to these electrodes and moving the charged particles, wherein the charged  
20 particles are colored in a first color, at least a portion of the area where the first electrode is placed in which the density of the charged particles cannot be kept high is colored in substantially the same color as the first color, at least a portion of  
25 the area where the first electrode is placed in which the density of the charged particles can be kept high is colored in a second color, when the charged

particles are placed so as to cover the first  
electrode, the first color is visually recognized,  
and when the charged particles are attracted to the  
second electrode and accumulated, said second color  
5 is visually recognized.

[0009]

[Embodying Aspects of the Invention]

Next, preferred embodiments of the present  
invention will be described with reference to Figs. 1  
10 to 3.

[0010]

An electrophoresis display apparatus according  
to this embodiment includes a first substrate 1 and a  
second substrate 2 which are disposed with a  
15 predetermined gap interposed therebetween and an  
insulating liquid 3 and a plurality of charged  
particles 4 are placed in the gap between the  
substrates 1 and 2. For each pixel A, a first  
electrode 5 and a second electrode 6 are placed. The  
20 first electrode 5 is placed along the back substrate  
in a relatively wide area (hereinafter referred to as  
"first electrode area")  $A_1$ . The second electrode 6  
is disposed along the first substrate 1 in Fig. 1 but  
may be disposed on a part (for example, within a  
25 barrier 7 which will be described later) apart from  
the first substrate 1 or may be disposed along the  
second electrode 2.

[0011]

Incidentally, it is supposed that the first electrode area means an area along the first substrate.

5 [0012]

Then,

▪ in the case that a voltage of one polarity is applied between the first electrode 5 and the second electrode 6, the charged particles 4 are attracted to the first electrode 5 and disposed to hide the first electrode 5, and

▪ in the case that a voltage of opposite polarity is applied between the first electrode 5 and the second electrode 6, the charged particles 4 are attracted to the second electrode 6 and accumulated thereon.

[0013]

The charged particles 4 are colored in one color (hereinafter, referred to as a "first color").

20 [0014]

In the case that the charged particles are disposed to hide the first electrode 5, it is preferable that the charged particles be disposed at an almost uniform density. However, it may sometimes occur that there generates a part where the density cannot be maintained high (for example, a part in the vicinity of the second electrode 6, a part which is

inclined due to formation of the barrier or a coated part). Therefore, according to the present invention, countermeasures are taken as follows.

5       •       Within the first electrode area  $A_1$ , at least a part of an area where the density of the charged particles cannot be maintained high (hereinafter, referred to as a "colored area") is colored in a color which is almost the same as the first color.

10       •       Within the first electrode area  $A_1$ , at least a part of an area where the density of the charged particles can be maintained high is colored in a second color.

15       •       As a result, in the case that the charged particles have been disposed to hide the first electrode 5, the first color of the charged particles is visually confirmed as the color of the pixel concerned.

20       •       While, in the case that the charged particles are attracted to the second electrode 6 and accumulated thereon, the second color is visually confirmed as the color of the pixel concerned.

[0015]

As examples of a method of coloring the first electrode area  $A_1$ ,

25       •       a method of coloring the first electrode itself,  
      •       a method of forming a colored layer instead of coloring the electrode and

- a method of coloring an insulation layer disposed to cover the first electrode can be given.

[0016]

5           In addition, as a method of coloring a colored area  $A_3$  (that is, within the first electrode area  $A_1$ , the area where the density of the charged particles cannot be maintained high), a method of providing a colored layer (designated by 8 in Fig. 1) which is  
10 colored in a color which is almost the same as the first color) can be given. As examples of this method,

- a method of applying a photosensitive resin layer in which a pigment is mixed with a dye to the  
15 area and then performing light exposure and wet development on the area and

- a method of forming the area by a printing method

can be given. The same coloring method may be  
20 adopted for the second color.

[0017]

The colored area  $A_3$  is preferably strip-shaped along the boundary between the first electrode 5 and the second electrode 6.

25 [0018]

When the colored area  $A_3$  is too wide, the part displaying the second color, that is, the proportion

of the part of the first electrode area  $A_1$  other than the colored area is reduced, causing visibility to be reduced when the second color is displayed. On the contrary, when the colored area  $A_3$  is too narrow, the same problem as that of the conventional art occurs, that is, when the first color is displayed, loss of color may occur. The area of the colored area  $A_3$  needs to be decided taking all these problems into consideration. More specifically, it is necessary to calculate the area and shape of the colored area  $A_3$  taking into account an area C (hereinafter referred to as "particle hiding area") of the first electrode area hidden behind charged particles when the charged particles are concentrated in the vicinity of the second electrode and an area E where the first electrode area is exposed because of an insufficient density of the charged particles (hereinafter referred to as "exposed area of the first area") when the charged particles are moved onto the first electrode.

[0019]

It is possible to place a barrier 7 between the substrates so as to partition a pixel. In that case, a second electrode 6 may be placed:

- (1) between the barrier 7 and the first substrate 1 as shown in Fig. 1 and Fig. 2,
- (2) at a position other than the position at which

the barrier 7 is placed as shown in Fig. 3 or  
(3) within the barrier 7 or between the barrier 7 and  
the second substrate 2 as described above.

[0020]

5           In the case (1) (a configuration that the  
charged particles 4 are not accumulated on the second  
electrode 6), the particle hiding area can be  
calculated on the basis of the pixel shape and a  
width across which the particles are accumulated  
10   calculated from the grain size of the charged  
particles. More precisely, it is possible to carry  
out field effect simulation to decide the shape of  
the particle hiding area along an equipotential line  
obtained when a voltage of the same polarity as that  
15   of the charged particles has been applied to the  
first electrode 5 and to decide the shape of a pixel  
aperture area along an equipotential line obtained  
when a voltage of the opposite polarity to that of  
the charged particles has been applied to the first  
20   electrode 5. It is also possible to calculate the  
area and the shape of the particle hiding area on the  
basis of results of optical observation performed  
when the charged particles have been gathered around  
the second electrode and when the particles have been  
25   moved onto the first electrode and it is also  
possible to calculate the area and the shape of the  
pixel aperture according to the actual situations.

Then, when the particle hiding area including the shape exceeds the exposed area of the first area, it is preferable to define the intermediate area and shape for the colored area  $A_3$ . In that case, the colored area  $A_3$  need not necessarily cover the entire width of accumulated charged particles. On the other hand, when the particle hiding area is smaller than the exposed area of the first area, it is necessary to decide the area of the colored area and the shape according to the priority level of light and shade, but from the standpoint of a pixel aperture ratio, it is desirable to set the area and the shape of the colored area to the particle hiding area or smaller.

[0021]

On the other hand, in the case (2), it is possible to calculate the particle hiding area and the pixel aperture area in the same manner as that in the case (1) to decide the area and the shape of the colored area  $A_3$  except that the area of a part where the charged particles advance from the second electrode into the pixel is defined as the particle hiding area.

[0022]

In the case (1), the colored layer

- may be disposed so as to cover not only the colored area  $A_3$  ( that is, the area where the density of the charged particles cannot be maintained high in



the first electrode disposed area) but also the second electrode 6 as shown by the numeral 8 in Fig. 1 or

- may be disposed to cover only the colored area  $A_3$  as shown by the numeral 18 in Fig. 2.

[0023]

Also, in the case (2), the colored layer

- may be disposed so as to cover not only the colored area  $A_3$  but also the second electrode 6 or
- 10 • may be disposed to cover only the colored area  $A_3$ .

[0024]

Next, respective components of the electrophoresis display apparatus will be described.

15 [0025]

It is preferable to place the barrier 7 in the gap between substrates so as to partition one pixel from another. It is possible to use polymer resin as this barrier 7 and more specifically, it is possible to use polyimide resin, polyester resin, polyacrylate resin, polymethacrylate resin, polycarbonate resin, polyallylate resin, novolac resin, epoxy resin, etc., as this barrier 7. Examples of the method of forming this barrier 7 include:

- 25 • Method of applying a photosensitive resin layer, then carrying out exposure and wet developing
- Method of forming support member 6 using a printing

method

- Method of forming a barrier and then adhering it to the substrate
  - Method of forming support member 6 on an optically transparent substrate surface through molding
- [0026]

For the substrate 1 and 2, it is possible to use a polymer film such as polyethylene terephthalate (PET), polyether sulfone (PES), polyimide (PI) and polyethylene naphthalate (PEN), polycarbonate (PC), an inorganic material such as glass and quartz or a stainless steel substrate, the surface of which includes an insulating layer. Note that for the substrate 2 on the observer side, it is possible to use a material with high transmittance of visible light such as a transparent polymer film and glass. Furthermore, it is also possible to form a resin layer (see reference numeral 42) made of a polymer material whose rubber hardness is within a range of 10 to 90, or more specifically silicon resin, natural rubber, thermoplastic elastomer resin on the surface of the substrate 2 (surface contacting the insulating liquid 3).

[0027]

Furthermore, it is possible to use any material for the electrodes 1 and 2 if it is at least a conductive material that can be patterned, for

example, indium tin oxide (ITO), aluminum and titanium. Note that in the electrophoresis display apparatus shown in Fig. 1, the first electrode 5 and second electrode 6 are formed at different heights (that is, a position offset with respect to the direction normal to the substrate), but they can also be formed at the same height. Furthermore, in the electrophoresis display apparatus shown in Fig. 1, the first electrodes 5 of different pixels are separated from one another and there is no electrical continuity among them, but it is also possible to provide electrical continuity among the first electrodes 5 of different pixels.

[0028]

It is preferable to form an insulating layer on the surfaces of these electrodes to

- insulate one electrode from another or
- prevent injection of charges from electrode to charged particles 4.

As a material used for this insulating layer, it is preferable to use a thin film in which pinholes are hardly formed. More specifically, polyimide resin, polyester resin, polyacrylate resin, polymethacrylate resin, polycarbonate resin, etc., having high transparency can be used.

[0029]

Furthermore, it is also possible to:

- place a scattering layer in front of the first electrode 5 (upper part in the figure) (see reference numeral 10) or
- make the first electrode 5 transparent and place a reflecting layer behind (lower part in the figure) (not shown).

As the scattering layer, it is possible to use a transparent insulating layer containing highly reflective micro particles and it is preferable to use titanium oxide or  $\text{Al}_2\text{O}_3$  as micro particles and acrylic resin, urethane resin, fluorine-based resin, norbornene resin, PC, PET, etc., can be used as the insulating resin. When the scattering layer is thick, it is possible to increase the reflective factor and improve the display quality, but on the contrary it is possible to cause the drive voltage to rise. Therefore, the thickness of the scattering layer is preferably within a range of 0.1 to 20  $\mu\text{m}$ .

[0030]

An average particle diameter of charged particles 4 used in the present invention is preferably within a range of 0.1  $\mu\text{m}$  or above and 10  $\mu\text{m}$  or below. The coloring agent is not particularly limited, but it can be, for example, carbon black, titanium oxide, barium sulfate, nigrosine, iron black, aniline blue, calcoil blue, chrome yellow, ultramarine blue, Du Pont oil red, quinoline yellow,

methylene blue chloride, phthalocyanine blue,  
phthalocyanine green, sky blue, rhodamine lake, etc.  
Furthermore, as particle resin, polystyrene,  
polyethylene, polyester, polymethacrylate,  
5 polyacrylate, polyacrylic ester, polyethylene-based  
resin such as polyethylene-acrylic acid copolymer,  
polyethylene-methacrylic acid copolymer,  
polyethylene-vinyl acetate copolymer, other polymer  
material such as polyvinyl chloride resin,  
10 nitrocellulose, phenol resin, and polyamide resin can  
be used. These materials can be used singly or with  
two or more types combined.

[0031]

As the insulating liquid 3, it is preferable to  
15 use a low-conductive, high-insulating organic solvent.  
Such a solvent can be aromatic hydrocarbon-based  
solvent such as benzene, toluene and xylene,  
aliphatic hydrocarbon-based solvent such as hexane,  
cyclohexane, paraffin-based hydrocarbon solvent,  
20 isoparaffin-based hydrocarbon and naphthene-based  
hydrocarbon, hydrocarbon halide-based solvent or  
silicon oil, high purity petroleum, etc., but above  
all, aliphatic hydrocarbon solvent is preferably used  
and more specifically, isopar-G, H, M, L  
25 (manufactured by Exxon Chemical), Shellsol (Showa  
Shell Japan), IP Solvent 1016, 1620, 2028, 2835  
(Idemitsu Petrochemical), etc., can be used. These

can be used singly or with two or more types combined.  
[0032]

The insulating liquid 3 may also contain additives such as charge control agent, dissociation  
5 stabilizer, scattering stabilizer for the purposes of increasing the amount of charge of charged particles or providing charge stability.  
[0033]

As the charge control agent, it is preferable  
10 to use metallic soap and more specifically, metallic soap such as cobalt naphthenate, zirconium naphthenate, copper naphthenate, iron naphthenate, lead naphthenate, manganese naphthenate, zinc naphthenate, cobalt octanate, zirconium octanate,  
15 iron octanate, lead octanate, nickel octanate, manganese octanate and zinc octanate can be used but the charge control agent is not limited to them.  
[0034]

Furthermore, rosin ester or rosin derivative  
20 can be used for the purposes of increasing the amount of charge of charged particles or providing charge stability. Rosin ester or rosin derivative is not particularly limited as far as it is soluble to the insulating liquid, but can be, for example, gum rosin,  
25 wood rosin, tallol rosin, rosin denatured maleic acid, rosin denatured pentaerythritol, rosin glycerin ester, partially hydrogen added rosin methyl ester,

partially hydrogen added rosin glycerin ester,  
partially hydrogen added rosin triethylene glycol  
ester, fully hydrogen added rosin pentaerythritol  
ester, maleic acid denatured rosin ester, fumaric  
5 acid denatured rosin ester, acrylic acid denatured  
rosin ester, maleic acid denatured rosin  
pentaerythritol ester, fumaric acid denatured rosin  
pentaerythritol ester, acrylic acid denatured rosin  
glycerin ester, maleic acid denatured rosin glycerin  
10 ester, fumaric acid denatured rosin glycerin ester  
and acrylic acid denatured rosin glycerin ester.  
[0035]

Specific examples of the scattering stabilizer  
include polybutadiene, polyisoprene, polyisobutylene,  
15 polybutene, styrene butadiene copolymer, styrene  
isoprene copolymer, styrene maleic anhydride  
copolymer, norbornene resin and polyethylene wax.  
Above all, styrene butadiene copolymer is preferable,  
for example, as commercially available materials, E-  
20 SBR, S-SBR (manufactured by JSR Corporation), NIPOL  
1502, NIPOL 1712, NIPOL NS112, NIPOL NS116, NIPOL  
1006, NIPOL 1009 (manufactured by Zeon Corporation),  
TAFDENE, TUFFPRENE, Asaprene (manufactured by Asahi  
Kasei Chemical Corporation), Sumitomo SBR  
25 (manufactured by Sumitomo Chemical Co., Ltd.), etc.,  
can be used.  
[0036]

In the present invention, these charge control agents, charge stabilizers and scattering stabilizers can be used singly or with two or more types combined.  
[0037]

5           Then, the effects of this embodiment will be explained.  
[0038]

          According to this embodiment, in the first electrode area  $A_1$ , the area where the density of the charged particles cannot be maintained high is at  
10           least partially colored in the color which is almost the same as the color (the first color) of the charged particles 4. Therefore, the color seen from the gaps of charged particles is simply substantially  
15           the same color as the first color and the low density of charged particles is hardly visually recognized, which prevents the display quality from deteriorating.  
[0039]

<Examples>

20           The present invention will be explained in more detail using Examples below.  
[0040]

(Example 1)

          In this example, an electrophoresis display  
25           apparatus  $D_1$  having the structure shown in Fig. 1 will be created.

[0041]



That is, a first substrate 1 and a second substrate 2 are arranged with a predetermined spacing in between, a barrier 7 is placed in the spacing between these substrates 1 and 2 so as to partition a pixel A and each pixel A is filled with an insulating liquid 3 and charged particles 4. Furthermore, each pixel A is provided with a first electrode 5 and second electrode 6 as shown in the figure. Then, a scattering layer 10 is formed on the entire substrate so as to cover the first electrode 5 and a colored layer 8 is placed in the areas  $A_2$  and  $A_3$  so as to cover the second electrode 6. Furthermore, the surfaces of the scattering layer 10, colored layer 8 and barrier 7 are coated with a transparent insulating layer 11. Furthermore, a resin layer 9 is formed on the surface of the second substrate 2 and an adhesion layer 12 is placed between the second substrate 2 and the barrier 7.

[0042]

In the present example, polystyrene particles (average particle diameter of  $2.5\ \mu\text{m}$ ) colored in black with carbon black (CB, average particle diameter of 80 nm) which is inorganic pigment is used as the charged particles 4, the colored layer 8 is also colored in black and the first electrode area  $A_1$  (to be precise, the part  $A_1$  which is the first electrode area except the area  $A_3$  where the colored

layer is placed) is designed to appear white through the function of the scattering layer 10.

[0043]

Then, the method of manufacturing the electrophoresis display apparatus will be explained.

[0044]

First, an aluminum film is formed to a thickness of 100 nm on the surface of the glass substrate 1 of 0.7 mm thick, which is then patterned to form the first electrode 5. Then, the polyurethane resin layer (scattering layer) 10 whitened by mixing titanium oxide micro particles is formed so as to cover this first electrode 5. Furthermore, a dark-colored carbonized titanium film is formed in the area  $A_2$ , patterned into a linear shape through photolithography and dry etching to form the second electrode 6. The second electrode 6 has a thickness of 50 nm and a line width of 12  $\mu\text{m}$ .

[0045]

Furthermore, the aforementioned colored layer 8 is formed. This colored layer 8 is linear-shaped so as to be placed not only in the area  $A_2$  where the second electrode 6 is formed but also in the area (see reference numeral  $A_3$ ) where the first electrode 5 is formed. Furthermore, this colored layer 8 is formed by applying photosensitive resin (CFPR-BK738S manufactured by Tokyo Ohka Kogyo Co., Ltd.) in which

pigment is scattered to a film thickness of 1  $\mu\text{m}$  using a spinner and patterning it through exposure and wet developing. This colored layer 5 has a width of 22  $\mu\text{m}$  and the area  $A_3$  has a width of 5  $\mu\text{m}$ .

5 [0046]

Then, by applying photosensitive epoxy resin (SU8 manufactured by MacDermid, Incorporated) followed by exposure and wet developing, the barrier 7 is formed in the area  $A_2$  where the second electrode 6 is formed. The barrier 7 has a height of 30  $\mu\text{m}$ , width of 12  $\mu\text{m}$  and spacing of 120  $\mu\text{m}$ . Then, the transparent resin layer 11 made of polyacrylate resin (optomer SS6699 manufactured by JSR Corporation) is formed so as to cover the inner surface of the cell.

15 [0047]

Then, the UV-cured adhesion layer 12 is formed on the top surface (surface to which the substrate 2 is pasted) of the barrier 7.

[0048]

20 Then, the concave section partitioned by the barrier 7 is filled with a scattering liquid mixed with charged particles 4. The scattering liquid is prepared by mixing the charged particles of 1 weight ratio, isopar-H (manufactured by Exxon Corporation)  
25 of 100 weight ratio which is an aliphatic hydrocarbon solvent, zirconium octanate (Nikka octics zirconium, manufactured by Nihon Kagaku Sangyo Co., Ltd.) of 0.1

weight ratio, rosin ester (NEOTALL 125H, manufactured by Harima Chemicals, Inc.) of 2.5 weight ratio and styrene butadiene copolymer (Asaprene 1205, manufactured by Asahi Kasei Chemicals Corporation) of 5 0.8 weight ratio and stirring it for one hour. Note that the charged polarity of the charged particles is negative.

[0049]

Finally, the substrate 2 made of a 10 polycarbonate film (100  $\mu\text{m}$  thick) is adhered to the barrier 7 and UV-cured to create the electrophoresis display apparatus of the present invention.

[0050]

The migrating state of the charge particles 15 when the rectangular wave of  $\pm 20\text{V}$  and  $0.5\text{Hz}$  had been applied was observed using the display apparatus manufactured in the above mentioned manner. When the voltage of  $-20\text{V}$  had been applied to the first electrode 5, the charged particles were accumulated 20 in the vicinity of the second electrode as shown in Fig. 1 and the pixel was displayed in white. On the other hand, when the voltage of  $+20\text{V}$  had been applied to the first electrode 5, the charged particles 4 were scattered over the first electrode 5 and no 25 white patch was found in the area  $A_3$  and good black brightness was confirmed.

[0051]

(Comparative Example 1)

The migrating state of the charged particles when the rectangular wave of  $\pm 20\text{V}$  and  $0.5\text{ Hz}$  had been applied was observed using the display apparatus  
5 manufactured in the same manner as that in the example 1 except that no colored layer 8 was formed. When the voltage of  $+20\text{v}$  had been applied to the first electrode 5, a white patch was observed in the area  $A_3$  and reduction of the black brightness was  
10 also observed.

[0052]

(Example 2)

In the present example, the electrophoresis display apparatus  $D_1$  shown in Fig. 2 will be created.  
15 This has a structural difference from the electrophoresis display apparatus shown in Fig. 1 in that the colored layer 18 is placed only in the area  $A_3$  (without placing it in the area  $A_2$  where the second electrode 6 is placed) and the rest of the structure  
20 and the manufacturing method are the same.

[0053]

Then, when the apparatus is driven in the same way as Example 1, the same display quality can be confirmed.

25 [0054]

(Example 3)

In the present example, the electrophoresis

display apparatus  $D_1$  shown in Fig. 3 will be created.  
That is, the second electrode 6 is placed not between  
the barrier 7 and the back substrate 1 but outside  
the area where the barrier 7 is placed and the  
5 colored layer 28 is placed so as to cover the second  
electrode 6 and stick out toward the first electrode  
3. Note that the second electrode 6 has a width of  
30  $\mu\text{m}$  and the colored layer 28 has a width of 35  $\mu\text{m}$ .  
The rest of the structure and the manufacturing  
10 method are the same as those in Example 1.  
[0055]

When the apparatus is driven in the same way as  
Example 1, the same display quality can be confirmed.  
[0056]

15 [Effect of the Invention]

As described above, according to the present  
invention, in the first electrode area, at least a  
part of the area where the density of the charged  
particles cannot be maintained high is colored in the  
almost the same color as the color (the first color)  
20 of the charged particles. Therefore, the color  
observed through between the charged particles is  
merely the almost the same color as the first color,  
the reduction in density of the charged particles is  
hardly visually observed and hence deterioration of  
25 the display quality can be reduced.

[Brief Description of the Drawings]

[Figure 1]

A sectional diagram showing one example of the structure of an electrophoresis display apparatus according to the present invention.

5 [Figure 2]

A sectional diagram showing another example of the structure of an electrophoresis display apparatus according to the present invention.

[Figure 3]

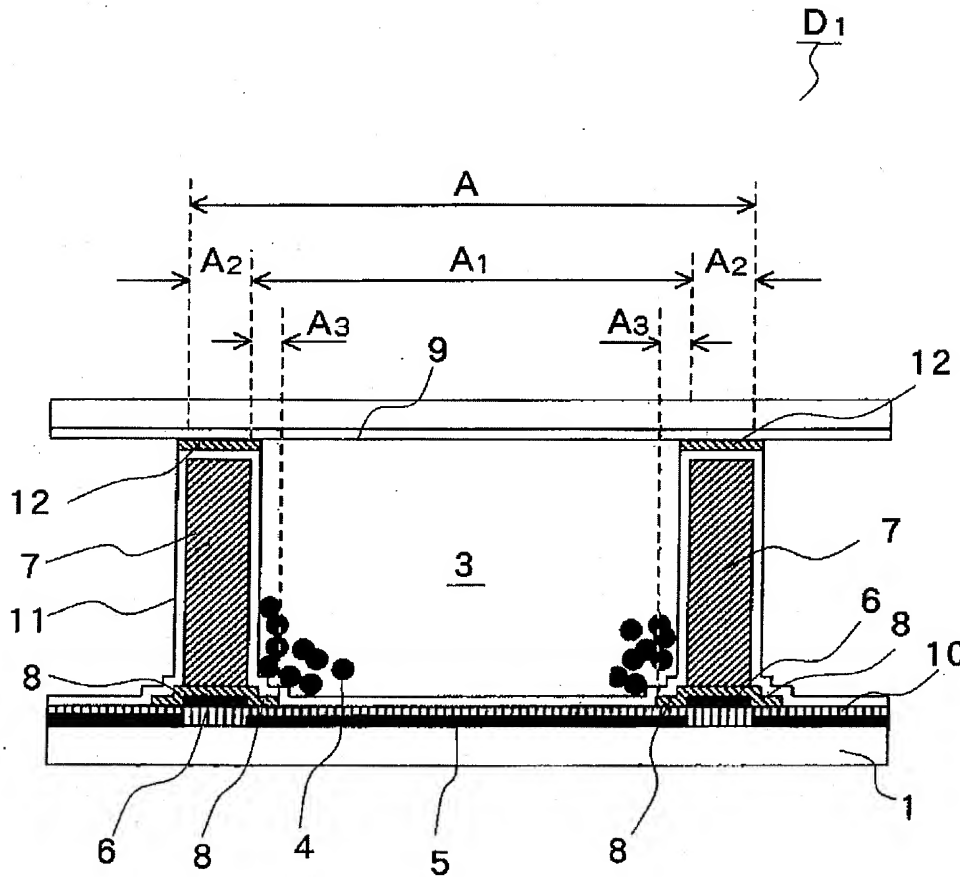
10 A sectional diagram showing a further example of the structure of an electrophoresis display apparatus according to the present invention.

[Description of Reference Numerals or Symbols]

- 1: first substrate
- 15 2: second substrate
- 3: insulating liquid
- 4: charged particles
- 5: first electrode
- 6: second electrode
- 20 7: barrier
- A<sub>1</sub>: first electrode disposed area
- A<sub>2</sub>: second electrode disposed area
- D<sub>1</sub>: electrophoresis display apparatus
- D<sub>2</sub>: electrophoresis display apparatus
- 25 D<sub>3</sub>: electrophoresis display apparatus

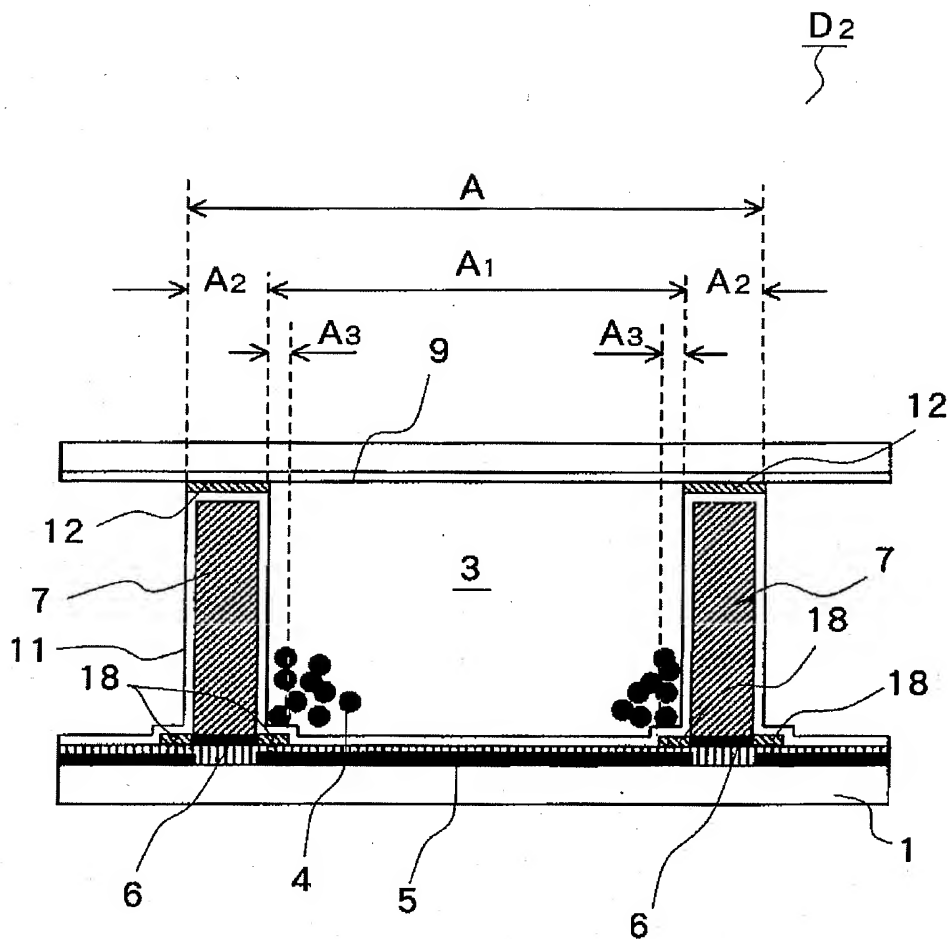
【書類名】 図面  
[Name of the Document] Drawings

【図1】  
[Fig. 1]

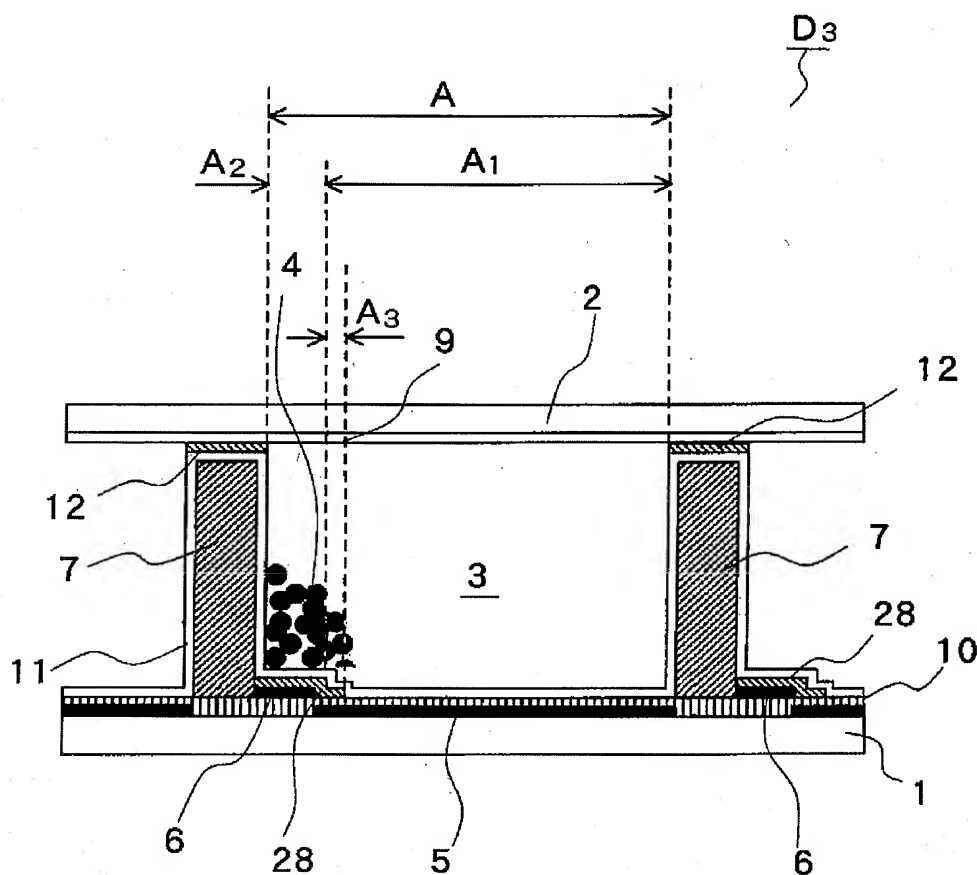




【図2】 [Fig. 2]



【図3】 [Fig. 3]



[Name of the Document] Abstract

[Abstract]

[Subject] To prevent display quality from being deteriorated.

5 [Solving Means]

When charged particles 4 are attracted to a first electrode 5, the distribution density may not become uniform over the entire area A1 and only the distribution density in the periphery of the first  
10 electrode 5 (see reference numeral A3) may be locally reduced. The present invention places a colored layer 8 having the same color as the color of charged particles in this area A3. Therefore, even if the distribution density is low, the low density is  
15 hardly visually recognized, making it possible to prevent the display quality from deteriorating.

[Elected Drawing] Figure 1

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Applicant's Information

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